

SHACL – Shapes Constraint Language in AllegroGraph

SHACL is a SHApE Constraint Language. It specifies a vocabulary (using triples) to describe the shape that data should have. The *shape* specifies things like the following simple requirements:

- How many triples with a specified subject and predicate should be in the repository (e.g. at least 1, at most 1, exactly 1).
- What the nature of the object of a triple with a specified subject and predicate should be (e.g. a string, an integer, etc.)

See the specification for more examples.

SHACL allows you to validate that your data is conforming to desired requirements.

For a given validation, the shapes are in the *Shapes Graph* (where *graph* means a collection of triples) and the data to be validated is in the *Data Graph* (again, a collection of triples). The SHACL vocabulary describes how a given shape is linked to *targets* in the data and also provides a way for a Data Graph to specify the Shapes Graph that should be used for validation. The result of a SHACL validation describes whether the Data Graph conforms to the Shapes Graph and, if it does not, describes each of the failures.

Namespaces Used in this Document

Along with standard predefined namespaces (such as `rdf:` for `<http://www.w3.org/1999/02/22-rdf-syntax-ns#>` and `rdfs:` for `<http://www.w3.org/2000/01/rdf-schema#>`), the following are used in code and examples below:

```
prefix fr: <https://franz.com#>
prefix sh: <http://www.w3.org/ns/shacl#>
prefix franz: <https://franz.com/ns/allegrograph/6.6.0/>
```

A Simple Example

Suppose we have a *Employee* class and for each Employee instance, there must be exactly one triple of the form

```
emp001 hasID "000-12-3456"
```

where the object is the employee's ID Number, which has the format is [3 digits]-[2 digits]-[4 digits].

This TriG file encapsulates the constraints above:

```
@prefix sh: <http://www.w3.org/ns/shacl#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

<https://franz.com#Shapes> {
  <https://franz.com#EmployeeShape>
    a sh:NodeShape ;
    sh:targetClass <https://franz.com#Employee> ;
    sh:property [
      sh:path <https://franz.com#hasID> ;
      sh:minCount 1 ;
      sh:maxCount 1 ;
      sh:datatype xsd:string ;
      sh:pattern "^[0-9][0-9][0-9]-[0-9][0-9]-
[0-9][0-9][0-9][0-9]$" ;
    ] .
}
```

It says that for instances of `fr:Employee` (`sh:targetClass <https://franz.com#Employee>`), there must be exactly 1 triple with predicate (path) `fr:hasID` and the object of that triple must be a string with pattern [3 digits]-[2 digits]-[4 digits] (`sh:pattern "^[0-9][0-9][0-9]-[0-9][0-9]-[0-9][0-9][0-9][0-9]$" .`).

This TriG file defines the Employee class and some employee instances:

```
@prefix fr: <https://franz.com#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .

{
  fr:Employee
    a rdfs:Class .
  fr:emp001
    a fr:Employee ;
    fr:hasID "000-12-3456" ;
    fr:hasID "000-77-3456" .
  fr:emp002
    a fr:Employee ;
    fr:hasID "00-56-3456" .
  fr:emp003
    a fr:Employee .
}
```

Recalling the requirements above, we immediately see these problems with these triples:

1. *emp001* has two *hasID* triples.
2. The value of *emp002*'s ID has the wrong format (two leading digits rather than 3).
3. *emp003* does not have a *hasID* triple.

We load the two TriG files into our repository, and end up with the following triple set. Note that all the employee triples use the default graph and the SHACL-related triples use the graph `<https://franz.com#Shapes>` specified in the TriG file.

| s | p | o | g |
|---------------|-------------|--|--------|
| Employee | rdf:type | rdfs:Class | |
| emp001 | rdf:type | Employee | |
| emp001 | hasID | "000-12-3456" | |
| emp001 | hasID | "000-77-3456" | |
| emp002 | rdf:type | Employee | |
| emp002 | hasID | "00-56-3456" | |
| emp003 | rdf:type | Employee | |
| EmployeeShape | property | _:b7A1D241Ax1 | Shapes |
| _:b7A1D241Ax1 | pattern | "^[0-9][0-9][0-9]-[0-9][0-9]-[0-9][0-9][0-9][0-9]\$" | Shapes |
| _:b7A1D241Ax1 | datatype | xs:string | Shapes |
| _:b7A1D241Ax1 | maxCount | "1" | Shapes |
| _:b7A1D241Ax1 | minCount | "1" | Shapes |
| _:b7A1D241Ax1 | path | hasID | Shapes |
| EmployeeShape | targetClass | Employee | Shapes |
| EmployeeShape | rdf:type | NodeShape | Shapes |

Now we use **agtool shacl-validate** to validate our data:

```
bin/agtool shacl-validate --data-graph default --shapes-graph
https://franz.com#Shapes shacl-repo-1
```

```
Validation report:          Does not conform
Created:                    2019-06-27T10:24:10
Number of shapes graphs:   1
Number of data graphs:     1
Number of NodeShapes:     1
Number of focus nodes checked: 3
```

3 validation results:

Result:

```
Focus node:                <https://franz.com#emp001>
Path:                      <https://franz.com#hasID>
Source Shape:              _:b7A1D241Ax1
                          Constraint                               Component:
<http://www.w3.org/ns/shacl#MaxCountConstraintComponent>
Severity:                  <http://www.w3.org/ns/shacl#Violation>
```

Result:

```
Focus node:                <https://franz.com#emp002>
Path:                      <https://franz.com#hasID>
Value:                     "00-56-3456"
Source Shape:              _:b7A1D241Ax1
                          Constraint                               Component:
<http://www.w3.org/ns/shacl#PatternConstraintComponent>
Severity:                  <http://www.w3.org/ns/shacl#Violation>
```

Result:

```

Focus node:          <https://franz.com#emp003>
Path:               <https://franz.com#hasID>
Source Shape:      _:b7A1D241Ax1
                   Constraint                               Component:
<http://www.w3.org/ns/shacl#MinCountConstraintComponent>
Severity:          <http://www.w3.org/ns/shacl#Violation>

```

The validation fails with the problems listed above. The **Focus node** is the subject of a triple that did not conform. **Path** is the predicate or a property path (predicates in this example). **Value** is the offending value. **Source Shape** is the shape that established the constraint (you must look at the shape triples to see exactly what **Source Shape** is requiring).

We revise our employee data with the following SPARQL expression, deleting one of the emp001 triples, deleting the emp002 triple and adding a new one with the correct format, and adding an emp003 triple.

```

prefix fr: <https://franz.com#>

DELETE DATA {fr:emp002 fr:hasID "00-56-3456" } ;

INSERT DATA {fr:emp002 fr:hasID "000-14-1772" } ;

DELETE DATA {fr:emp001 fr:hasID "000-77-3456" } ;

INSERT DATA {fr:emp003 fr:hasID "000-54-9662" } ;

```

Now our employee triples are

| s | p | o | g |
|----------|----------|---------------|---|
| emp002 | hasID | "000-14-1772" | |
| emp003 | hasID | "000-54-9662" | |
| Employee | rdf:type | rdfs:Class | |
| emp001 | rdf:type | Employee | |
| emp001 | hasID | "000-12-3456" | |
| emp002 | rdf:type | Employee | |
| emp003 | rdf:type | Employee | |

We run the validation again and are told our data conforms:

```

% bin/agtool shacl-validate --data-graph default --shapes-graph https://franz.com#Shapes shacl-repo-1

```

| | |
|--------------------------------|---------------------|
| Validation report: | Conforms |
| Created: | 2019-06-27T10:32:19 |
| Number of shapes graphs: | 1 |
| Number of data graphs: | 1 |
| Number of NodeShapes: | 1 |
| Number of focus nodes checked: | 3 |

When we refer to this example in the remainder of this document, it is to the un-updated (incorrect) triples.

SHACL API

The example above illustrates the SHACL steps:

1. Have a data set with triples that should conform to a shape
2. Have SHACL triples that express the desired shape
3. Run SHACL validation to determine if the data conforms

Note that SHACL validation does not modify the data being validated. Once you have the conformance report, you must modify the data to fix the conformance problems and then rerun the validation test.

The main entry point to the API is **agtool shacl-validate**. It takes various options and has several output choices. Online help for **agtool shacl-validate** is displayed by running `agtool shacl-validate --help`.

In order to validate triples, the system must know:

1. What triples to examine
2. What rules (SHACL triples) to use
3. What to do with the results

Specifying what triples to examine

Two arguments to **agtool shacl-validate** specify the triples to evaluate: `--data-graph` and `--focus-node`. Each can be specified

multiple times.

- The `--data-graph` argument specifies the graph value for triples to be examined. Its value must be an IRI or default. Only triples in the specified graphs will be examined. `default` specifies the default graph. It is also the default value of the `--data-graph` argument. If no value is specified for `--data-graph`, only triples in the default graph will be examined. If a value for `--data-graph` is specified, triples in the default graph will only be examined if `--data-graph default` is also specified.
- The `--focus-node` argument specifies IRIs which are subjects of triples. If this argument is specified, only triples with these subjects will be examined. To be examined, triples must also have graph values specified by `--data-graph` arguments. `--focus-node` does not have a default value. If unspecified, all triples in the specified data graphs will be examined. This argument can be specified multiple times.

The `--data-graph` argument was used in the simple example above. Here is how the `--focus-node` argument can be used to restrict validation to triples with subjects `<https://franz.com#emp002>` and `<https://franz.com#emp003>` and to ignore triples with subject `<https://franz.com#emp001>` (applying **agtool shacl-validate** to the original non-conformant data):

```
% bin/agtool shacl-validate --data-graph default \  
  --shapes-graph https://franz.com#Shapes \  
  --focus-node https://franz.com#emp003 \  
  --focus-node https://franz.com#emp002 shacl-repo-1  
Validation report:          Does not conform  
Created:                   2019-06-27T11:37:49  
Number of shapes graphs:   1  
Number of data graphs:     1  
Number of NodeShapes:     1  
Number of focus nodes checked: 2
```

2 validation results:

Result:

```
Focus node:      <https://franz.com#emp003>
Path:           <https://franz.com#hasID>
Source Shape:   _:b7A1D241Ax2
                Constraint
                Component:
<http://www.w3.org/ns/shacl#MinCountConstraintComponent>
Severity:       <http://www.w3.org/ns/shacl#Violation>
```

Result:

```
Focus node:      <https://franz.com#emp002>
Path:           <https://franz.com#hasID>
Value:          "00-56-3456"
Source Shape:   _:b7A1D241Ax2
                Constraint
                Component:
<http://www.w3.org/ns/shacl#PatternConstraintComponent>
Severity:       <http://www.w3.org/ns/shacl#Violation>
```

Specifying What Shape Triples to Use

Two arguments to **agtool shacl-validate**, analogous to the two arguments for data described above, specify Shape triples to use. Further, following the SHACL spec, data triples with predicate `<http://www.w3.org/ns/shacl#shapeGraph>` also specify graphs containing Shape triples to be used.

The arguments to **agtool shacl-validate** are the following. Each may be specified multiple times.

- The `--shapes-graph` argument specifies the graph value for shape triples to be used for SHACL validation. Its value must be an IRI or default. default specifies the default graph. The `--shapes-graph` argument has no default value. If unspecified, graphs specified by data triples with the `<http://www.w3.org/ns/shacl#shapeGraph>` predicate will be used (they are used whether or not `--shapes-graph` has a value). If `--shapes-graph` has no value and there are no data triples with

the `<http://www.w3.org/ns/shacl#shapeGraph>` predicate, the data graphs are used for shape graphs. (Shape triples have a known format and so can be identified among the data triples.)

- The `--shape` argument specifies IRIs which are subjects of shape nodes. If this argument is specified, only shape triples with these subjects and subsidiary triples to these will be used for validation. To be included, the triples must also have graph values specified by the `--shapes-graph` arguments or specified by a data triple with the `<http://www.w3.org/ns/shacl#shapeGraph>` predicate. `--shape` does not have a default value. If unspecified, all shapes in the shapes graphs will be used.

Other APIs

There is a lisp API using the function `validate-data-graph`, defined next:

```
validate-data-graphdb &key data-graph-iri/s shapes-graph-iri/s shape/s focus-node/s verbose conformance-only?  
function
```

Perform SHACL validation and return a validation-report structure.

The validation uses `data-graph-iri/s` to construct the `dataGraph`. This can be a single IRI, a list of IRIs or `NIL`, in which case the default graph will be used. The `shapesGraph` can be specified using the `shapes-graph-iri/s` parameter which can also be a single IRI or a list of IRIs. If `shape-graph-iri/s` is not specified, the SHACL processor will first look to create the `shapesGraph` by finding triples with the predicate `sh:shapeGraph` in the `dataGraph`. If there are no such triples, then the `shapesGraph` will be assumed to be the same as the `dataGraph`.

Validation can be restricted to particular shapes and focus nodes using the `shape/s` and `focus-node/s` parameters. Each of these can be an IRI or list of IRIs.

If `conformance-only?` is true, then validation will stop as soon as any validation failures are detected.

You can use `validation-report-conforms-p` to see whether or not the `dataGraph` conforms to the `shapesGraph` (possibly restricted to just particular `shape/s` and `focus-node/s`).

The function `validation-report-conforms-p` returns `t` or `nil` as the validation struct returned by `validate-data-graph` does or does not conform.

`validation-report-conforms-preport`
function

Returns `t` or `nil` to indicate whether or not `REPORT` (a `validation-report` struct) indicates that validation conformed. There is also a REST API. See HTTP reference.

Validation Output

The simple example above and the SHACL examples below show output from `agtool validate-shacl`. There are various output formats, specified by the `--output` option. Those examples use the plain format, which means printing results descriptively. Other choices include `json`, `trig`, `trix`, `turtle`, `nquads`, `rdf-n3`, `rdf/xml`, and `ntriples`. Here are the simple example (uncorrected) results using `ntriples` output:

```
% bin/agtool shacl-validate --output ntriples --data-graph
default --shapes-graph https://franz.com#Shapes shacl-repo-1
```

```
_ :b271983AAx1
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.w3.org/ns/shacl#ValidationReport> .
```

_:b271983AAx1 <http://www.w3.org/ns/shacl#conforms>
"false"^^<http://www.w3.org/2001/XMLSchema#boolean> .
_:b271983AAx1 <http://purl.org/dc/terms/created>
"2019-07-01T18:26:03"^^<http://www.w3.org/2001/XMLSchema#dateTime> .
_:b271983AAx1 <http://www.w3.org/ns/shacl#result>
_:b271983AAx2 .
_:b271983AAx2
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.w3.org/ns/shacl#ValidationResult> .
_:b271983AAx2 <http://www.w3.org/ns/shacl#focusNode>
<https://franz.com#emp001> .
_:b271983AAx2 <http://www.w3.org/ns/shacl#resultPath>
<https://franz.com#hasID> .
_:b271983AAx2 <http://www.w3.org/ns/shacl#resultSeverity>
<http://www.w3.org/ns/shacl#Violation> .
_:b271983AAx2
<http://www.w3.org/ns/shacl#sourceConstraintComponent>
<http://www.w3.org/ns/shacl#MaxCountConstraintComponent> .
_:b271983AAx2 <http://www.w3.org/ns/shacl#sourceShape>
_:b271983AAx3 .
_:b271983AAx1 <http://www.w3.org/ns/shacl#result>
_:b271983AAx4 .
_:b271983AAx4
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.w3.org/ns/shacl#ValidationResult> .
_:b271983AAx4 <http://www.w3.org/ns/shacl#focusNode>
<https://franz.com#emp002> .
_:b271983AAx4 <http://www.w3.org/ns/shacl#resultPath>
<https://franz.com#hasID> .
_:b271983AAx4 <http://www.w3.org/ns/shacl#resultSeverity>
<http://www.w3.org/ns/shacl#Violation> .
_:b271983AAx4
<http://www.w3.org/ns/shacl#sourceConstraintComponent>
<http://www.w3.org/ns/shacl#PatternConstraintComponent> .
_:b271983AAx4 <http://www.w3.org/ns/shacl#sourceShape>
_:b271983AAx3 .
_:b271983AAx4 <http://www.w3.org/ns/shacl#value> "00-56-3456"
.
_:b271983AAx1 <http://www.w3.org/ns/shacl#result>
_:b271983AAx5 .

```

_:b271983AAx5
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.w3.org/ns/shacl#ValidationResult> .
_:b271983AAx5      <http://www.w3.org/ns/shacl#focusNode>
<https://franz.com#emp003> .
_:b271983AAx5      <http://www.w3.org/ns/shacl#resultPath>
<https://franz.com#hasID> .
_:b271983AAx5      <http://www.w3.org/ns/shacl#resultSeverity>
<http://www.w3.org/ns/shacl#Violation> .
_:b271983AAx5
<http://www.w3.org/ns/shacl#sourceConstraintComponent>
<http://www.w3.org/ns/shacl#MinCountConstraintComponent> .
_:b271983AAx5      <http://www.w3.org/ns/shacl#sourceShape>
_:b271983AAx3 .

```

You can have the triples added to the repository by specifying the `--add-to-repo` option `true`.

In the plain output information is provided about how many data graphs are examined, how many shape graphs were specified and node shapes are found, and how many focus nodes are checked. If zero focus nodes are checked, that is likely not what you want and something has gone wrong. Here we mis-spell the name of the shape graph (`https://franz.com#shapes` instead of `https://franz.com#Shapes`) and get 0 focus nodes checked:

```

% bin/agtool shacl-validate --data-graph default --shapes-graph https://franz.com#shapes shacl-repo-1
Validation report:           Conforms
Created:                     2019-06-28T10:34:22
Number of shapes graphs:     1
Number of data graphs:       1
Number of NodeShapes:        0
Number of focus nodes checked: 0

```

SPARQL integration

There are two sets of magic properties defined: one checks for basic conformance and the other produces validation reports as triples:

- `?valid franz:shaclConforms (?dataGraph [?shapesGraph])`
- `?valid franz:shaclFocusNodeConforms1 (?dataGraph ?nodeOrNodeCollection)`
- `?valid franz:shaclFocusNodeConforms2 (?dataGraph ?shapesGraph ?nodeOrNodeCollection)`
- `?valid franz:shaclShapeConforms1 (?dataGraph ?shapeOrShapeCollection [?nodeOrNodeCollection])`
- `?valid franz:shaclShapeConforms2 (?dataGraph ?shapesGraph ?shapeOrShapeCollection [?nodeOrNodeCollection])`
- `(?s ?p ?o) franz:shaclValidationReport (?dataGraph [?shapesGraph])`
- `(?s ?p ?o) franz:shaclFocusNodeValidationReport1 (?dataGraph ?nodeOrNodeCollection) .`
- `(?s ?p ?o) franz:shaclFocusNodeValidationReport2 (?dataGraph ?shapesGraph ?nodeOrNodeCollection) .`
- `(?s ?p ?o) franz:shaclShapeValidationReport1 (?dataGraph ?shapeOrShapeCollection [?nodeOrNodeCollection]) .`
- `(?s ?p ?o) franz:shaclShapeValidationReport2 (?dataGraph ?shapesGraph ?shapeOrShapeCollection [?nodeOrNodeCollection]) .`

In all of the above `?dataGraph` and `?shapesGraph` can be IRIs, the literal 'default', or a variable that is bound to a SPARQL collection (list or set) that was previously created with a function

like <https://franz.com/ns/allegrograph/6.5.0/fn#makeSPARQLList> or <https://franz.com/ns/allegrograph/6.5.0/fn#lookupRdfList>.

If a collection is used, then the SHACL processor will create a temporary RDF merge of all of the graphs in it to produce the data graph or the shapes graph.

Similarly, `?shapeOrShapeCollection` and `?nodeOrNodeCollection` can be bound to an IRI or a SPARQL collection. If a collection is used, then it must be bound to a list of IRIs. The SHACL

processor will restrict validation to the shape(s) and focus node(s) (i.e. nodes that should be validated) specified.

The `shapesGraph` argument is optional in both of the `shaclConforms` and `shaclValidationReport` magic properties. If the `shapesGraph` is not specified, then the `shapesGraph` will be created by following triples in the `dataGraph` that use the `sh:shapesGraph` predicate. If there are no such triples, then the `shapesGraph` will be the same as the `dataGraph`.

For example, the following SPARQL expression

```
construct { ?s ?p ?o } where {
  # form a collection of focusNodes
  bind(<https://franz.com/ns/allegrograph/6.6.0/fn#makeSPARQLList>(
    <http://Journal1/1942/Article25>,
    <http://Journal1/1943>) as ?nodes)
    (?s ?p ?o)
  <https://franz.com/ns/allegrograph/6.6.0/shaclShapeValidationReport1>
    ('default' <ex://franz.com/documentShape1> ?nodes) .
}
```

would use the default graph as the Data Graph and the Shapes Graph and then validate two focus nodes against the shape `<ex://franz.com/documentShape1>`.

SHACL Example

We build on our simple example above. Start with a fresh repository so triples from the simple example do not interfere with this example.

We start with a TriG file with various shapes defined on some classes.

```
@prefix sh: <http://www.w3.org/ns/shacl#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix fr: <https://franz.com#> .
```

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
```

```
<https://franz.com#ShapesGraph> {
fr:EmployeeShape
  a sh:NodeShape ;
  sh:targetClass fr:Employee ;
  sh:property [
    ## Every employee must have exactly one ID
    sh:path fr:hasID ;
    sh:minCount 1 ;
    sh:maxCount 1 ;
    sh:datatype xsd:string ;
    sh:pattern "[0-9][0-9][0-9]-[0-9][0-9]-
[0-9][0-9][0-9][0-9]$" ;
  ] ;
  sh:property [
    ## Every employee is a manager or a worker
    sh:path fr:employeeType ;
    sh:minCount 1 ;
    sh:maxCount 1 ;
    sh:datatype xsd:string ;
    sh:in ("Manager" "Worker") ;
  ] ;
  sh:property [
    ## If birthyear supplied, must be 2001 or before
    sh:path fr:birthYear ;
    sh:maxInclusive 2001 ;
    sh:datatype xsd:integer ;
  ] ;
  sh:property [
    ## Must have a title, may have more than one
    sh:path fr:hasTitle ;
    sh:datatype xsd:string ;
    sh:minCount 1 ;
  ] ;

  sh:or (
    ## The President does not have a supervisor
    [
      sh:path fr:hasTitle ;
```

```

        sh:hasValue "President" ;
    ]
    [
        ## Must have a supervisor
        sh:path fr:hasSupervisor ;
        sh:minCount 1 ;
        sh:maxCount 1 ;
        sh:class fr:Employee ;
    ]
) ;

sh:or (
    # Every employee must either have a wage or a salary
    [
        sh:path fr:hasSalary ;
        sh:datatype xsd:integer ;
        sh:minInclusive 3000 ;
        sh:minCount 1 ;
        sh:maxCount 1 ;
    ]
    [
        sh:path fr:hasWage ;
        sh:datatype xsd:decimal ;
        sh:minExclusive 15.00 ;
        sh:minCount 1 ;
        sh:maxCount 1 ;
    ]
)
.
}

```

This file says the following about instances of the class `fr:Employee`:

1. Every employee must have exactly one ID (object of `fr:hasID`), a string of the form `NNN-NN-NNNN` where the `Ns` are digits (this is the simple example requirement).
2. Every employee must have exactly one `fr:employeeType` triple with value either `"Manager"` or `"Worker"`.

3. Employees may have a `fr:birthYear` triple, and if so, the value must be 2001 or earlier.
4. Employees must have a `fr:hasTitle` and may have more than one.
5. All employees except the one with title "President" must have a supervisor (specified with `fr:hasSupervisor`).
6. Every employee must either have a wage (a decimal specifying hourly pay, greater than 15.00) or a salary (an integer specifying monthly pay, greater than or equal to 3000).

Here is some employee data:

```
@prefix fr: <https://franz.com#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
```

```
{
  fr:Employee
    a rdfs:Class .

  fr:emp001
    a fr:Employee ;
    fr:hasID "000-12-3456" ;
    fr:hasTitle "President" ;
    fr:employeeType "Manager" ;
    fr:birthYear "1953"^^xsd:integer ;
    fr:hasSalary "10000"^^xsd:integer .

  fr:emp002
    a fr:Employee ;
    fr:hasID "000-56-3456" ;
    fr:hasTitle "Foreman" ;
    fr:employeeType "Worker" ;
    fr:birthYear "1966"^^xsd:integer ;
    fr:hasSupervisor fr:emp003 ;
    fr:hasWage "20.20"^^xsd:decimal .

  fr:emp003
    a fr:Employee ;
```

fr:hasID "000-77-3232" ;
fr:hasTitle "Production Manager" ;
fr:employeeType "Manager" ;
fr:birthYear "1968"^^xsd:integer ;
fr:hasSupervisor fr:emp001 ;
fr:hasSalary "4000"^^xsd:integer .

fr:emp004

a fr:Employee ;
fr:hasID "000-88-3456" ;
fr:hasTitle "Fitter" ;
fr:employeeType "Worker" ;
fr:birthYear "1979"^^xsd:integer ;
fr:hasSupervisor fr:emp002 ;
fr:hasWage "17.20"^^xsd:decimal .

fr:emp005

a fr:Employee ;
fr:hasID "000-99-3492" ;
fr:hasTitle "Fitter" ;
fr:employeeType "Worker" ;
fr:birthYear "2000"^^xsd:integer ;
fr:hasWage "17.20"^^xsd:decimal .

fr:emp006

a fr:Employee ;
fr:hasID "000-78-5592" ;
fr:hasTitle "Filer" ;
fr:employeeType "Intern" ;
fr:birthYear "2003"^^xsd:integer ;
fr:hasSupervisor fr:emp002 ;
fr:hasWage "14.20"^^xsd:decimal .

fr:emp007

a fr:Employee ;
fr:hasID "000-77-3232" ;
fr:hasTitle "Sales Manager" ;
fr:hasTitle "Vice President" ;
fr:employeeType "Manager" ;
fr:birthYear "1962"^^xsd:integer ;
fr:hasSupervisor fr:emp001 ;

```
    fr:hasSalary "7000"^^xsd:integer .
}
```

Comparing these data with the requirements, we see these problems:

1. emp005 does not have a supervisor.
2. emp006 is pretty messed up, with (1) employeeType "Intern", not an allowed value, (2) a birthYear (2003) later than the required maximum of 2001, and (3) a wage (14.40) less than the minimum (15.00).

Otherwise the data seems OK.

We load these two TriG files into an empty repository (which we have named **shacl-repo-2**). We specify the default graph for the data and the `https://franz.com#ShapesGraph` for the shapes. (Though not required, it is a good idea to specify a graph for shape data as it makes it easy to delete and reload shapes while developing.) We have 101 triples, 49 data and 52 shape. Then we run **agtool shacl-validate**:

```
% bin/agtool shacl-validate --shapes-graph
https://franz.com#ShapesGraph --data-graph default shacl-
repo-2
```

There are four violations, as expected, one for emp005 and three for emp006.

| | |
|--------------------------------|---------------------|
| Validation report: | Does not conform |
| Created: | 2019-07-03T11:35:27 |
| Number of shapes graphs: | 1 |
| Number of data graphs: | 1 |
| Number of NodeShapes: | 1 |
| Number of focus nodes checked: | 7 |

4 validation results:

Result:

| | |
|---------------|-----------------------------------|
| Focus node: | <https://franz.com#emp005> |
| Value: | <https://franz.com#emp005> |
| Source Shape: | <https://franz.com#EmployeeShape> |

```
Constraint Component:
<https://www.w3.org/ns/shacl#OrConstraintComponent>
Severity: <https://www.w3.org/ns/shacl#Violation>
```

```
Result:
Focus node: <https://franz.com#emp006>
Path: <https://franz.com#employeeType>
Value: "Intern"
Source Shape: _:b19D062B9x221
```

```
Constraint Component:
<http://www.w3.org/ns/shacl#InConstraintComponent>
Severity: <http://www.w3.org/ns/shacl#Violation>
```

```
Result:
Focus node: <https://franz.com#emp006>
Path: <https://franz.com#birthYear>
Value:
"2003"^^<http://www.w3.org/2001/XMLSchema#integer>
Source Shape: _:b19D062B9x225
```

```
Constraint Component:
<http://www.w3.org/ns/shacl#MaxInclusiveConstraintComponent>
Severity: <http://www.w3.org/ns/shacl#Violation>
```

```
Result:
Focus node: <https://franz.com#emp006>
Value: <https://franz.com#emp006>
Source Shape: <https://franz.com#EmployeeShape>
```

```
Constraint Component:
<http://www.w3.org/ns/shacl#OrConstraintComponent>
Severity: <http://www.w3.org/ns/shacl#Violation>
```

Fixing the data is left as an exercise for the reader.